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Henry Versus Thompson Approach for Fixation of Proximal Third Radial Shaft Fractures: A Multicenter Study

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(Justification for multiple authors: given that this was a multi-center study performed at 11 level one academic institutions, those who contributed to the project were included as an author in the manuscript)

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Running head:
Fixation of Proximal Third Radial Shaft Fractures

Abstract:

Objective: Compare the volar Henry and dorsal Thompson approaches with respect to outcomes and complications for proximal third radial shaft fractures.

Design: Multi-center retrospective cohort study.

Patients/Participants: Patients with proximal third radial shaft fractures ± associated ulna fractures (OTA/AO 2R1 ± 2U1) treated operatively at 11 trauma centers.

Intervention: Demographic patient, injury, fracture, and surgical data were recorded. Final ROM and complications of infection, neurologic injury, compartment syndrome, and mal/non-union were compared for volar vs. dorsal approaches.

Main outcome: Difference in complications between patients treated with volar versus dorsal approach.

Results: At an average follow up of 292 days, 202 patients (range, 18-84 years) with proximal third radial shaft fractures were followed through union or nonunion. 155 were fixed via volar and 47 via dorsal approach. Patients treated via dorsal approach had fractures that were on average 16mm more proximal than those approached volarly, which didn't translate to more screw fixation proximal to the fracture. Complications occurred in 11% of volar and 21% of dorsal approaches with no statistical difference.

Conclusion: There was no statistical difference in complication rates between volar and dorsal approaches. Specifically, fixation to the level of the tuberosity is safely accomplished via the volar approach. This series demonstrates the safety of the volar Henry approach for proximal 1/3 radial shaft fractures.

Level of evidence: III

Key words: radial shaft fracture; proximal radial shaft fracture; volar vs dorsal approach

MANUSCRIPT:

Introduction:

Both the volar [1] and dorsal [2] approaches have been proposed for the fixation of proximal radius shaft fractures [1-9]. The dorsal approach, between the extensor carpi radialis brevis and extensor digitorum communis, has been recommended by various authors and texts for fractures in the proximal third of the radial shaft (see Figure, Supplemental Digital Content 1, http://links.lww.com/JOT/A872)[2, 6]. The benefits of the dorsal approach include: the superficial location of the radius at this location making it easily accessible, the ability to potentially place fixation more proximally as compared to the volar approach, and the ability to directly observe and protect the posterior interosseous nerve (PIN) [3, 4].

Despite this recommendation, many surgeons use the volar Henry approach between the supinator and the pronator teres (see Figure, Supplemental Digital Content 2, http://links.lww.com/JOT/A873.) [1]. Advantages of the volar approach are: better soft tissue coverage of implants, greater familiarity of the approach, and the ability to avoid direct dissection of the PIN [3, 4]. One potential drawback of the volar approach previously reported is the biceps insertion, which has been stated to limit the proximal exposure, cause impingement, and potentially affect the ability to place fixation directly on the radius' volar surface [3].

Given the varied recommend approaches for fractures in the proximal third of the radius, specific factors were compared between the two approaches. Since the volar approach involves a larger soft tissue dissection than the dorsal, the rate of synostosis, superficial infection, deep infection, and wound dehiscence were compared. Also since the volar approach directly involves exposing the forearm vasculature, differences in compartment syndrome and vascular injury were included as study factors. Given that there has been reported concern of fixation limitation using the volar approach for this short segment fixation, loss of reduction, implant failure, nonunion, and malunion rates were also included in the investigation. Additionally, injury to the PIN was included as the two approaches interact with the nerve differently. These factors comprise the complications identified in the study and were chosen given the unique differences between the volar and dorsal approaches.

The primary outcome of the study was to compare overall complication rates of volar versus dorsal approaches in patients who had fixation of the proximal third of the radial shaft. The null hypothesis was that there was no significant difference in the complications between the volar and dorsal approach groups.

Methods:

We performed a retrospective chart review on all patients with proximal third radial shaft fractures (OTA/AO 2R1 ± 2U1)[10] treated at 11 institutions over a ten tear period. Each institution had dedicated reviewers that consisted of an attending and resident, medical student, and/or physician assistant who searched their individual databases to identify the patients. Each study sites' principle investigator was responsible to make the radiographic determination of the fracture and fixation characteristics. We included skeletally mature patients ≥ 18 years old with radius fractures that extended into the proximal third of the shaft. Patients with associated ipsilateral ulna fracture and/or dislocation were included. Patients were excluded if they were < 18 years old, skeletally immature, treated non-operatively, had radial head and/or neck fractures, had pathologic fractures, were not followed to union/nonunion or had missing chart or radiographic information regarding complications.

We collected patient demographic information including: age, sex, body mass index, hand dominance, and history of diabetes and smoking. Injury characteristics included mechanism of injury, open vs closed fracture, worker's compensation, prior trauma and/or surgery to the extremity, associated injuries, and the presence of an ulna fracture or distal radial-ulnar joint (DRUJ) dislocation. Radiographic review performed by the chart reviewer included the pattern of the radius (and ulna) fractures, location of radius fracture described as percentage of total bone length, and presence of dislocation at elbow or distal radial-ulnar joint (Table #1).

Treatment data for the radius fracture fixation included: the type of plate used (size), number of plates used, plate length, number of plate holes proximal to the fracture, number of screws used proximal to the fracture, location of the proximal aspect of the plate in relation to the radial tuberosity, lag screw use, operating time, and use of bone graft / void filler (Table #2).

Outcomes included: complications, nonunion, and status of return to work. Complications were defined as: synostosis, superficial infection, deep infection, wound dehiscence, loss of reduction and implant failure, nonunion, malunion, compartment syndrome, PIN nerve injury, and vascular injury (Table #3). The primary outcome was differences in complications between patients treated with volar versus dorsal approach.

All factors were compared between the two groups investigated. Continuous variables were assessed with a Student's T-test and categorical variables were analyzed using Fisher's exact test. QuickCalcs on GraphPad Software was used for statistical analysis. A p-value of <0.05 was considered statistically significant.

All institutions obtained IRB approval. There was no funding used for this study.

Results:

There were a total of 202 patients included in the final analysis over a 10 year period with 155 in the volar and 47 in the dorsal group with 66 transverse, 36 oblique, 80 comminuted, and 20 segmental fractures. There were 109 males (70%) and 46 females (30%) in the volar group and

29 males (62%) and 18 females (38%) in the dorsal group (p=0.29). The average patient age was 36 years old (range: 18 – 81) in the volar approach group and 40 years old (range: 18 – 84) in the dorsal group (p =0.03). The average time to follow up was 275 days (range: 41-2,577) in the volar group and 347 days (range: 42-1,382) in the dorsal group (p=0.22).

There was no statistical differences between the two groups with regards to mechanism of injury, associated injuries, number of open fractures, radius or ulna fracture patterns, rate and location of ulna fracture, or rate and location of dislocation. This information is summarized in (Table #1). There was also no difference between the groups in the length of OR time, graft use, number of plates used, number of lag screws used, or plate length. However patients treated using a dorsal approach had fractures that extended more proximally than those treated via a volar approach with respect to the distance from the elbow at the radiocapitellar joint to the proximal most aspect of the fracture (85 mm in the volar group and 69 mm in the dorsal group; p=0.0001).

When counting the number of available plate screw holes proximal to the most proximal aspect of the fracture, those treated through a volar approach had an average of 3.6 plate holes available while those with a dorsal approach had an average of 3.3 plate holes available (p=0.02). However, this did not translate to more filled plate screw holes proximal to the fracture with the average being 3.1 vs 3.0 filled holes in the volar and dorsal groups (p=0.15). Additionally, there was no difference in the percentage of patients who had plates engaging or proximal to the bicipital tuberosity (47% volar and 55% dorsal) or the average distance plates were placed proximal to the tuberosity in these patients. Finally, the presence of an ulna fracture did not influence outcomes.

The union rate was 95% for the volar and 87% for the dorsal groups (p=0.10). The combined complication rate for the dorsal approach was 21% vs 11% for the volar group, but this did not reach statistical significance (p=0.09). There were three deep infections that all were in the volar group: two were open fractures (p=1), and there were two PIN nerve injuries in each group (p=0.23) (Table #3).

The complication rate between open and closed fractures in the volar group was 14% vs 8%, respectively (p=0.28) whereas it was 32% for open fractures and 12% for closed fractures in the dorsal group (p=0.15). The average overall arc of prono-supination in the volar and dorsal groups was 156° and 148° (p=0.30), respectively. The overall elbow ROM average was 129° in the volar group (range: 0-160°) and 124° in the dorsal group (range: 0-160°) (p=0.32). The return to work rate was also similar between the groups with 53% in the volar vs 51% in the dorsal (p=0.87).

Discussion:

Fixation in the proximal third of the radial shaft can be challenging because of the limited amount of space to place implants. The dorsal approach has been recommended for the proximal third of the radial shaft, but many surgeons choose to use a volar approach instead. Despite the volar approach's common use, it has not been well described in the literature.

To date, the only comparison of the approaches has been on fractures in the proximal half of the radius by Mehdi Nasab et al who compared 39 volar to 31 dorsal approach patients and found no significant differences in union, infection, or nerve injury rates [4]. These investigators included fractures in the entire proximal half of the radial shaft but did not report the proximal most extent of the fracture. This limits the conclusions centered around short segment fixation and the limits of the two approaches in the very proximal forearm where these differences are most pronounced. To further clarify this question, various outcome factors of the volar versus dorsal approaches for proximal third radial shaft fractures were evaluated in our study.

Historical concerns about the use of the volar approach for proximal third fractures include the safety of the PIN and the ability to obtain sufficient fixation in a short proximal fragment due to the steric limitation of the bicep's insertion. The potential advantages of the volar Henry approach, as compared with a dorsal Thompson approach, include easy distal extension for greater exposure, more robust soft tissue coverage of implants, and avoidance of direct dissection of the posterior interosseous nerve (PIN). Preserving the PIN within the supinator with the volar approach may minimize scarring around the nerve, which can be significant given that PIN injury is more likely to occur during a repeat dorsal approach operation because of the scaring around the nerve [3, 11]. Additionally as the volar approach is more standard in the distal two-thirds of the radius, it is much more familiar to many surgeons.

The dorsal approach has the advantage of a greater proximal length of exposure and the ability to explore and decompress the PIN directly. However, dissection of the PIN within the supinator may be technically difficult, which can especially become more challenging in revision cases [3, 11].

Our data demonstrated that there was a statistical difference in surgeons choosing a dorsal approach for fractures that were located more proximally. Despite the difference in fracture location between the groups, there was a similar number of proximal screw holes filled with a statistically different but clinically similar number of plate holes proximal to the fracture site. Additionally, there was a significantly higher rate of plates that were placed proximal to the bicipital tuberosity in the dorsal group; however there was no statistical difference in the ability to place the plate proximal to the bicipital tuberosity between the groups. This suggests that the biceps insertion, in fact, may not be a limiting factor when using the volar approach as previously reported. Further supporting this notion, double plating was utilized in similar numbers between the two groups. Thus, while the dorsal approach theoretically allows for a greater length of available bone to place fixation, this may not be clinically important.

The advent of locked fixation may also play a role as short segment fixation stability is more secure when locked [12]. Additionally, there was no statistical differences in the rate of complications between the groups, suggesting that either approach may be acceptable for these types of fractures. Patients with open versus closed fractures trended to have higher complication rates for both approaches. Finally, the union rate was higher in the volar group, but this did not reach significance.

Our primary limitation is the multi-center, retrospective nature of this evaluation, which is limited by how well data was originally documented in the chart. Specifically, outcomes such as union rate needs to be interpreted carefully as there was not a pre-determined definition of union and each respective study site was responsible to make this determination. Also, there was a dissimilar number of those who had a volar versus dorsal approach, which may be a reflection of surgeon/institution bias and/or fracture pattern. An example of this is that there were more comminuted fractures approached dorsally (51 vs 36%), which may infer that more severe fractures were preferentially treated via the dorsal approach. Additionally, this study is underpowered to demonstrate a difference in the complication rates between the two groups given that previously reported rates are low. Despite these limitations, this study reports a relatively large series of patients with proximal third radial shaft fractures treated effectively with both volar and dorsal approaches.

In conclusion, there was no significant difference found in rates of complications when comparing the volar and dorsal approaches. These results suggest that both the volar Henry and dorsal Thompson approaches are acceptable for fixation of fractures in the proximal third of the radial shaft. The choice of volar versus dorsal approach for these fractures should depend on such factors as surgeon's experience and soft tissue injuries (ie open fractures).

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TABLES:

Table 1

Demographics			
	Volar (n=155)	Dorsal (n=47)	p-value
Male	109 (70%)	29 (62%)	0.29
Female	46 (30%)	18 (38%)	
Workman's Compensation	11 (7%)	7 (15%)	0.14
Prior Injury / Surgery	7 (5%)	3 (6%)	0.70
Dominant Side Involved	Volar (n=155)	Dorsal (n=47)	p-value
Yes	47 (30%)	17 (36%)	0.48
No	59 (38%)	14 (30%)	0.39
Unknown	49 (32%)	16 (34%)	0.86
Mechanism	Volar (n=155)	Dorsal (n=47)	p-value
Motor vehicle / motorcycle crash	76 (49%)	24 (51%)	0.87
Fall from standing	31 (20%)	4 (9%)	0.08
Gunshot wound	18 (12%)	7 (15%)	0.61
Pedestrian struck	8 (5%)	1 (2%)	0.69
Fall from height	6 (4%)	1 (2%)	1.00
Other	16 (10%)	10 (21%)	0.08
Associated Injuries	Volar (n=155)	Dorsal (n=47)	p-value
None	76 (49%)	28 (60%)	0.24

Lower extremity	42 (27%)	8 (17%)	0.18
Thorax	19 (12%)	6 (13%)	1.00
Head	19 (12%)	3 (6%)	0.42
Abdominal	17 (11%)	3 (6%)	0.58
Pelvic / acetabular	14 (9%)	4 (9%)	1.00
Spine	10 (6%)	4 (9%)	0.74
Gustilo Open Fracture Type	Volar (n=155)	Dorsal (n=47)	p-value
None	98 (63%)	25 (53%)	0.24
I	26 (17%)	9 (19%)	0.67
II	9 (6%)	5 (11%)	0.32
IIIA	10 (6%)	6 (13%)	0.21
IIIB	8 (5%)	2 (4%)	1.00
IIIC	4 (3%)	0 (0%)	0.58
Radius Fracture Pattern	Volar (n=155)	Dorsal (n=47)	p-value
Transverse	55 (35%)	11 (23%)	0.16
Oblique	27 (17%)	9 (19%)	0.83
Comminuted	56 (36%)	24 (51%)	0.09
Segmental	17 (11%)	3 (6%)	0.58
Location of Proximal Aspect of Radius Fracture	Volar (n=155)	Dorsal (n=47)	p-value
Distance to Radiocapitellar Joint	85 mm	69 mm	**0.0001**
% Length to Radiocapitellar Joint	33.20%	27.70%	**0.0006**

Associated Ulna Fracture	Volar (n=155)	Dorsal (n=47)	p-value
Yes	53 (34%)	21 (45%)	0.23
No	102 (66%)	26 (55%)	
Ulna Fracture Location	Volar (n=155)	Dorsal (n=47)	p-value
Distal third	44 (28%)	15 (32%)	0.77
Midshaft	64 (41%)	19 (40%)	1.00
Proximal third	33 (21%)	10 (21%)	1.00
Unknown	9 (6%)	6 (13%)	0.12
Associated Dislocation	Volar (n=155)	Dorsal (n=47)	p-value
None	147 (95%)	46 (98%)	0.69
Elbow	3 (2%)	1 (2%)	1.00
Distal Radial Ulnar Joint	5 (3%)	0 (0%)	0.59

Table 2

Treatment Characteristics			
	Volar (n=155)	Dorsal (n=47)	p-value
Length of OR	183 min	157 min	0.14
Graft Use	7 (5%)	1 (2%)	0.68
Lag Screw Use	42 (27%)	10 (21%)	0.57
Two Plates Used on Radius	19 (12%)	4 (9%)	0.61
Plate Size (in mm)			
3.5	97 (63%)	30 (64%)	1
2.7/3.5	5 (3%)	0 (0%)	0.59
2.7	15 (10%)	5 (11%)	0.79
2.4	0 (0%)	1 (2%)	0.23
2	1 (1%)	0 (0%)	1
unknown	37 (24%)	11 (23%)	0.54
Average Plate Length	9 holes	8 holes	0.13
Average # of Plate Holes Proximal to Fracture	3.6 holes	3.3 holes	**0.02**
Average # Holes Filled in Plate Proximal to Fracture	3.1 holes	3.0 holes	0.15
Plate Location Relative to Bicipital Tuberosity			
Distal to Tuberosity	74 (48%)	20 (43%)	0.62
Engaging Tuberosity	57 (37%)	10 (21%)	0.05
Proximal to Tuberosity	16 (10%)	16 (34%)	**0.0004**
Not Recorded	8 (5%)	1 (2%)	0.69
Distance of Plate Proximal to Bicipital Tuberosity (range)	10.8 mm (3-24 mm)	11.2 mm (3-31 mm)	0.87

Table 3

Complications			
	Volar n=155	Dorsal n=47	p-value
Complication Event*	17 (11%)	10 (21%)	0.09
Synostosis	2 (1.3%)	2 (4.3%)	0.23
Superficial Infection	0 (0%)	0 (0%)	1.00
Deep Infection	3 (1.9%)	0 (0%)	1.00
Wound Dehiscence	0 (0%)	0 (0%)	1.00
Loss of reduction & implant failure	2 (1.3%)	0 (0%)	1.00
Nonunion	8 (5.2%)	6 (13%)	1.00
Malunion	1 (0.6%)	0 (0%)	1.00
Compartment Syndrome	2 (1.3%)	0 (0%)	1.00
PIN Nerve Injury	2 (1.3%)	2 (4.3%)	0.23
Vascular Injury**	1 (0.6%)	0 (0%)	1.00

*N=4 patients in the volar group and N=0 in the dorsal group had more than one complication

**Volar group had one radial artery injury intra-op that required repair